# Language and science in young learners

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# Chapter 5

## Attitudes of teachers towards teaching science in early elementary classrooms before and after individual video feedback coaching

This chapter is submitted as:
Menninga, A., Van Dijk, M, Steenbeek, H, & Van Geert, P. (submitted). Attitudes of teachers towards teaching science in early elementary classrooms before and after individual video feedback coaching.

## 5.1 Introduction

Teaching science is increasingly important in kindergarten and elementary school in view of fulfilling the demands of the 21st century (e.g. Esbach & Fried, 2005; French, 2004; Greenfield, Jirout, Dominguez, Greenberg, Maier & Fuccillo 2009; Saavedra & Opfer, 2012). Therefore, many programs around the world have started to introduce science in early elementary classrooms (French, 2004; Greenfield et al., 2009; Klein, Hammrich, Bloom & Ragins, 2000; Kramer & Rabe-Kleberg, 2011; National Research Council, 2013; Neumann, Fischer, & Kauertz, 2010). In the Netherlands, a national research program called Curious Minds was initiated to promote the importance and possibilities of science for young children (Steenbeek, Van Geert, & Van Dijk, 2011; Van Benthem, Dijkgraaf, & De Lange, 2005). In this research program, several interventions have been designed to introduce and improve science education in elementary school. Previous studies have shown that these interventions are effective in that teachers shift from a more closed and instructional way of teaching to a more open and stimulating way. As a result, students' reasoning skills are shown to improve (Wetzels, 2015; Van Vondel, 2016).

The current study is based on the data from a project in the Curious Minds program called "Language as a Tool for learning science," (LaT) which was designed to develop and implement an intervention for teachers focusing on integrating science and language learning. This intervention was carried out in 25 early elementary classrooms in which the teacher performed science activities with a small group of students. In the intervention condition, teachers received (video feedback) coaching based on video observations of real-time teacher-student interactions during their science activities. This form of professional development for teachers has proven to be effective in the way that teachers can be successfully trained to implement questioning and language modeling strategies, which has positive effects on reasoning and language use of students (see Chapter 4). The effectiveness of video feedback coaching for teachers – for instance on changes in verbal interaction style – was also shown in previous studies (Fukkink & Taveccio, 2010; Kennedy, Landor, & Todd, 2011; Seidel, Stürmer, Blomberg, Kobarg & Schwindt, 2011; Strathie, Strathie, & Kennedy, 2011; Van den Heijkant, et al., 2006). So far, the effectiveness of the LaT intervention was evaluated by focusing on the behavior of teacher and students in the classroom. The evaluation showed positive changes in teachers' use of open-ended questions, and complex and sophisticated language as well as increases in students' reasoning, and complex and sophisticated language use (see Chapter 4). However, aside from this component, teacher knowledge and attitude towards teaching science are also relevant when examining the effectiveness of an intervention (Garet, Porter, Desimone, Birman, & Yoon, 2001; Desimone, 2009; Van Aalderen-Smeets & Walma Van der Molen, 2013). Considering these attitudes and beliefs is of fundamental importance during such an intervention, since positive feelings and feelings of control towards teaching science contribute to teachers' willingness to change their behavior (Haney, Czerniak, & Lumpe, 1996; Van Aalderen-Smeets & Walma Van der Molen, 2013). The pre-existing mindsets of teachers influence the way they put what they learn in professionalization trainings into practice in their

classrooms (Fetters, Czerniak, Fish, & Shawberry, 2002; Roehrig, Kruse, & Kern, 2007). Although studies suggest that changing teachers' attitudes can be accomplished through professional development focusing on inquiry-based courses, making this change happen is still a major challenge (e.g., Bleicher, 2007; Bleicher & Lindgren, 2005; Choi & Ramsey, 2009; Lederman et al., 2014; Pedersen & McCurdy, 1992; Sanger, 2008; Weinburgh, 2007; Jarvis & Pell, 2004). The goal of the current study is, therefore, to investigate whether the intervention LaT also has an impact on teachers' attitudes towards science.

### 5.1.1 Attitudes and beliefs towards teaching science

There is general agreement that attitude can be understood as a psychological tendency to respond negatively or positively towards a certain object, idea, or situation (Ajzen, 2001). In existing literature, attitude as a construct consists of three components: cognition, affect, and behavior (Eagly & Chaiken, 1993). In a recent review study, Van Aalderen-Smeets, Walma Van der Molen, and Asma (2012) developed a theoretical framework for attitudes of elementary school teachers toward teaching science. This framework consists of three main dimensions: cognitive beliefs, affect, and perceived control. The first dimension, *cognitive beliefs*, refers to the perceived relevance of teaching science, the perceived difficulty of teaching science, and gender stereotypical beliefs regarding science (teaching). The second dimension, which is *affect*, encompasses the positive (enjoyment) and negative (anxiety) feelings of teachers toward teaching science. The third dimension, which is *perceived control*, relates to feelings of capability toward teaching science (self-efficacy) and feelings of dependency on contextual factors such as the availability of existing teaching methods. Van Aalderen-Smeets et al (2012) argue that an instrument based on this framework can be used to measure teachers' attitudes toward teaching science, and that their instrument, which is called Dimensions of Attitude toward Science (DAS) (Van Aalderen-Smeets & Walma Van der Molen, 2013), can be used to reliably do this. The authors also suggest that the framework may be helpful when designing and evaluating interventions that address the attitudes of teachers toward science teaching, in the way that they can be used to make the intervention more adaptive to the need of individual teachers (Lumpe, Hany, & Czerniak, 2000; Van Aalderen-Smeets et al., 2012).

Several studies suggest that early elementary teachers tend to have negative attitudes and beliefs towards teaching science (Appleton, 2003; Eshach, 2003; Greenfield et al., 2009; Murphy, Neil, & Beggs, 2007; Kallery, 2004; Osborne et al., 2003; Pederson & McCurdy, 1992; Sac¸kes, Trundle, Bell, & O'Connell, 2011; Tu, 2006; Watters, Diezmann, Grieshaber & Davis, 2000; Wenner, 2001). Teachers often state that they feel incompetent to provide high quality science lessons due to limited knowledge, time, material et cetera, and they report low confidence in answering (unexpected) student questions about science. Teaching science can be daunting when experienced as additional to existing teaching responsibilities and as a content area beyond your knowledge scope (Tu, 2006). The attitudes and beliefs towards teaching science are important when implementing science into the early elementary curriculum, as these aspects are associated with teachers' classroom behavior (Keys & Bryan,

2001; Richardson, 2003). For instance, positive attitudes are related to the time spent on teaching hands-on and inquiry science activities (Lakshmanan, Heath, Perlmutter, & Elder, 2011). Also, teachers nowadays experience great pressure to prioritize language and literacy activities over science, which negatively affects the amount of time spent on science activities (Greenfield et al., 2009). In sum, many studies report on negative attitudes toward teaching science, and since these attitudes are of great importance for successfully improving science in elementary education, the DAS questionnaire can be used to investigate teachers' attitudes (Van Aalderen-Smeets et al., 2011; Van Aalderen-Smeets & Walma Van der Molen, 2013).

### 5.1.2 Teaching experience and attitudes toward science

In general, research indicates that starting teachers – or novice teachers – often have more sophisticated ideas about instruction in general than they are able to put into practice. For instance, novice teachers often exhibit teaching practices that are contrary to what they claim to believe (Breen, Hird, Milton, Oliver, & Thwaite, 2001; Feryok, 2004; Mitchell, 2005; Pham & Hamid, 2013; Wang, Chai, & Hairon, 2016). Lumpe et al. (2000) found that experienced teachers demonstrated more positive feelings of perceived control than relative starters. Murphy and Smith (2012) evaluated the impact of a science course on attitudes of novice teachers toward science teaching. Although the findings showed positive outcomes on content knowledge, the participating novice teachers were still concerned that this knowledge was insufficient. They also reported concerns about teaching methodologies and classroom management issues (Murphy & Smith, 2012). Lotter (2004) found that, during a yearlong science program, novice teachers acknowledged that an inquiry-approach – which is an open pedagogical method in which students are challenged to actively participated in order to (co-)construct knowledge instead of listening to instructions and information of the teacher – was a useful method to teach science. However, they also encountered frustration and difficulties in their teaching practices, which were mostly related to negative attitudes of their students.

Although existing research suggests that experienced teachers are more effective in terms of student achievement, novice teachers improve the most during the first years of their careers (Clotfelter, Ladd, & Vigdor, 2007; Harris & Sass, 2007; Kane, Rocko, & Staiger, 2006). When novice teachers gain sufficient teaching experience, and they can address some of the more immediate concerns in learning to teach, their teacher effectiveness (and thus student outcomes) may change. Novice teachers, for instance, become more comfortable with the teaching role and with classroom management, and develop confidence in content knowledge. This may lead to a shift from focusing on their own teaching process to focusing on students' learning process, which may be reflected in their attitudes toward teaching.

### 5.1.3 The present study

This study describes the effects on teachers' attitudes after participation in the LaT video feedback coaching intervention. This intervention is based on inquiry learning principles,

pedagogical-didactical and language teaching strategies for teachers. The main aim was to improve students' reasoning expressions and language use by focusing on changing the verbal behavior of the teacher. The components underlying the intervention were the implementation of the empirical cycle, the use of open-ended questioning skills of teachers, and the deployment of language as a tool during science activities. By implementing the intervention, we intended to show (novice and experienced) teachers how they can teach science to four-to-six-year-old students in a simple and effective way, and how important it is to combine science and language learning. Multiple video feedback coaching sessions on an individual basis were used as a method of reflection upon teachers' own behavior and corresponding student reactions. The focus was on positive moments and seeing opportunities. The naturalistic classroom setting in which the intervention was conducted and the method of individual video feedback coaching on real-time behavior provided opportunities for teachers to continue practicing these principles in their daily teaching routines.

In this paper, we explore what the attitudes of experienced teachers and novice teachers toward teaching science are, what the underlying structure of the attitudes is, and whether –and on what dimensions– they differ before and after the intervention. It may be expected that teachers' attitudes become more positive after the intervention, because the aim of the intervention is to provide teachers with information and tools on how to teach science, and how to combine science and language learning. We may also find a difference between experienced and novice teachers in that the attitudes of novices are, at first, more negative than the experienced teachers' attitudes but that, at the same time, they show the highest increase after the intervention compared the experienced teachers. In the control condition, we expect less clear changes in attitude since there is no intervention that takes place. For all groups, we expect large differences between the individual teachers, as learning and development are idiosyncratic processes (Molenaar, 2004; Rose, Rouhani & Fischer, 2013).

## 5.2 Method

### 5.2.1 Participants

Seventeen experienced teachers (all female) and eight novice teachers[14] (seven female/one male) with a small group of students participated in this study. Eleven experienced teachers and all eight novice teachers participated in the intervention group, while the six other experienced teachers were part of the control group. Since all participants had signed up on a voluntary basis, the control group was in fact a waiting list. At the start of the data collection, the average age of teachers in the intervention group was 40 (range 27-60) with an average experience as a teacher of 14 years (range 3-33). In the control group, the average age of the teachers was 47 (range 34-59) and their average years of teaching experience were 19 (range 2-38). These two groups were comparable with regard to age and experience. The novice teachers were all

[14] Note: when it is not necessary to distinguish between novice teachers and experienced teachers, they are referred to as *teachers*.

student teachers in their final year of teacher education enrolled in the general teacher training bachelor program at the Hanze University of Applied Studies in Groningen (minor course in early elementary education). They were on average 23 years old (range 21-26) and they had four years of teacher-training experience each based on their yearly internships. During teacher education, the novice teachers had already followed a short theoretical course on teaching science in elementary school. The teachers and parents of the participating students gave informed consent before the start of the study with these procedures being approved by the Ethical Committee Psychology of the University of Groningen.

### 5.2.2 Materials and measures

***DAS questionnaire.***

To examine the attitudes of teachers towards teaching science, we used a validated and reliable instrument called *Development of Attitude toward Science* (DAS)(Van Aalderen-Smeets, & Walma Van der Molen, 2013). This questionnaire consists of the dimensions cognition, affect, and perceived control, which cover seven subcomponents that represent different beliefs and feelings toward teaching science. The cognitive dimension consists of statements representing the relevance and importance of teaching science in early elementary for the future, the perceived difficulty of teaching science in early elementary school, and gender-stereotypical beliefs about teaching science. The affect domain consists of items comprising positive and negative feelings and emotions related to teaching science. The perceived control domain consists of statements concerning the amount of perceived control teachers experience with regard to their own science teaching. In total, the questionnaire comprised 28 statements, and for each statement, participants were asked to indicate to what extent they agreed or disagreed on a five-point Likert scale, ranging from totally disagree to totally agree (see Appendix A for an overview of the statements per dimension). Based on the responses, a weighted sum-score was computed for each of the dimensions.

### 5.2.3 Procedure

The teachers were recruited by means of flyers and personalized emails from schools in the North of the Netherlands. Before the start of the intervention, the experienced and the novice teachers (intervention condition) filled in the DAS questionnaire. When they were part of the intervention group, teachers were instructed to give eight science lessons (15-20 minutes) on a topic of their own choice to a small teaching group within a period of 3-4 months. The first two lessons took place before the intervention started. After the second lesson, the teachers (experienced and novice) were provided with information, best-practice video clips and tools on the empirical cycle, open-ended questioning strategies, scaffolding, and language learning strategies during an information meeting. During lessons three to six teachers received individual video feedback coaching immediately after each science lesson (intervention). Two to four weeks after the final coaching session, teachers gave two further lessons. After

participation in the intervention, both the experienced and the novice teachers completed the DAS questionnaire for the second time (post-intervention measure DAS).

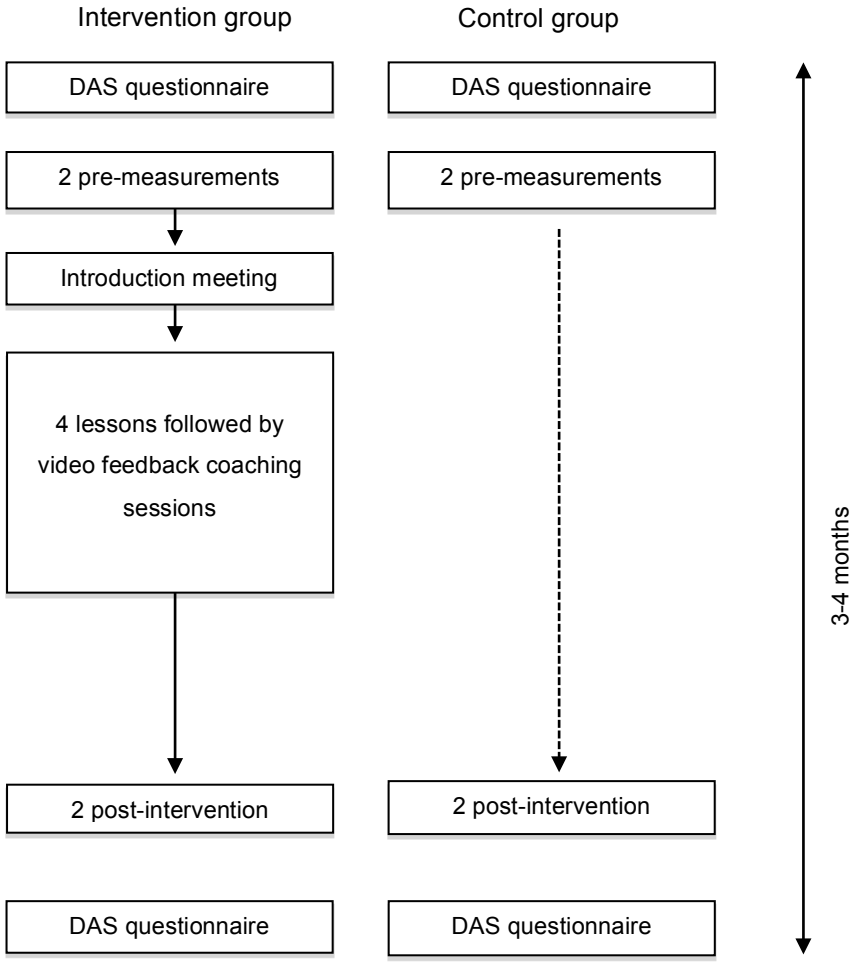


**Figure 1** Overview of the design of the study

The teachers in the control condition were given the same instruction as the teachers in the intervention condition: teach science 'as usual' on a topic of your own choice. Before the start of their first science lesson, they completed the DAS questionnaire (pre-measure). The control group was observed during two pre-intervention measures and approximately three months later – similar to the intervention condition– during two post-intervention measures. In the period between those measures, the control group did not receive any instructions or feedback. After the last science lesson, the teachers filled in the DAS questionnaire for the second time (post-intervention measure). The control teachers indicated that they taught science on a regular basis (on average once to three times a month) in the period between pre- and post-intervention measurements. Figure 1 provides an overview of the design of the study.

### 5.2.4 Analysis

For the purpose of describing the attitudes of teachers at the start of the intervention, the percentages of responses per subscale in the DAS questionnaire were calculated. Although the DAS instrument took into account the disadvantage of including a midpoint within a Likert-scale by only labelling the extremes (so that 1 is totally disagree, 5 is totally agree, and 2-4 have no label), it is hard to interpret the midpoint in terms of the subjective meaning that participants assign to this. For the interpretation of the scores in this paper, we describe the values 1 and 2 negatively and 4 and 5 positively, disregarding the midpoint as 3 in the DAS instrument is the midpoint on a sliding scale from disagree to agree, which is conceptually different from, for instance, a neutral label.

***Permutation tests.***

The average changes in attitudes before and after the intervention were investigated. For all the seven components of the DAS, the average score was calculated for each group (which means the experienced, novices, and control group). Pre- and post-intervention measures of the DAS questionnaire were compared using Monte Carlo permutation tests, as the assumptions of traditional statistics could not be met due to the small sample size (Todman & Dugard, 2001). A Monte Carlo analysis (Good, 2006) is a nonparametric test, which evaluates the null hypothesis that the probability of the difference between the pre- and post-intervention measures within groups or the difference between groups is based on chance alone. In this procedure, data are randomly sampled multiple times in order to determine whether the empirically found difference (i.e., within or between groups) could be expected based only on chance. The Monte Carlo permutation test provides an estimation of the exact *p* value, which is the probability that the same or a better difference is found if the null hypothesis is supported. The greater the number of permutations, the closer this estimation comes to the exact value (see Gigerenzer, 2004; Schneider, 2015), and therefore, data of this study were randomly shuffled 10,000 times. Monte Carlo analyses were performed in Microsoft Excel in combination with PopTools (version 3.2). In addition, effect size values were computed using Cohen's *d*, and interpreted as small (.20 or -.20), medium (.50 or -.50) or large effects (.80 or -.80) (Cohen, 1992; Sullivan & Feinn, 2012). Only when the empirically-found difference had a very small probability of being produced under the null-hypothesis – with a *p* value smaller than .05 and a *d* value larger than .50 (or -.50) – was it interpreted as strong evidence in support of the hypothesis. Empirical results with *p* values between .05 and .10 and an effect size larger than .50 (or -0.50) were interpreted as providing weak support for rejecting the null hypothesis.

***Visualization of changes.***

Scatterplots were created to visualize how the individual participants changed from pre- to post-measurement with regard to all seven sub dimensions of the DAS. Using Microsoft Excel, we plotted the scores of each individual in a scatterplot in which the pre-intervention measures defined the x-axis and the post-intervention measures the Y-axis. This scatterplot also

contained an isocline, which is a line connecting all scores for which no change occurs between pre- and post measurement. This is an artificially constructed line – based on all pre-measures – that serves as a line of comparison for all real scores. A real score falls above the isocline if it corresponds with positive change (increase) in attitude, and below the isocline if it corresponds with negative change (decrease). By scrutinizing the distribution of the scores vis-à-vis the isocline, one can easily determine the distribution of the changes across the group, for instance, whether positive changes occur in the great majority of individuals, whether an average difference between small subgroups is due to a typical outlier, and so forth.

***Correspondence analysis.***

The last aim was to explore the underlying structure of the attitude variables, and to assess whether this structure changed from pre- to post-intervention measure. Correspondence analysis was used, which is a descriptive (visualization) technique that provides results similar in nature to those produced by factorial analysis (Greenacre, 1984). The correspondence analysis was performed using Tanagra[15] (Rakotomalala, 2005), free data mining software. The dataset consisted of one set of the (average) scores per participant in all conditions on each of the seven sub dimensions of the DAS questionnaire at pre-intervention and one set of these scores at post-intervention measure. In addition, we constructed per condition (i.e. experienced teachers, novices, and controls) the 'average' participant on each sub dimension, and included this average participant into the correspondence analysis. Correspondence analysis basically reveals the association between rows and columns in a large contingency table. This method computes axes, which are latent variables that can be interpreted in order to understand the proximities between rows and/or columns. The analysis was performed for the pre- and post-intervention measures separately. In each dataset (pre- and post-intervention), there were seven columns (of the seven sub dimensions) and 27 rows (all participants plus three constructed average participants), and the Euclidean distances between the 27 rows in the 7-dimensional space were computed. The resulting distances provide information about the similarities between the rows (the participants) and are a reduced, lower-dimensional representation of the variables. The axes (or coordinates) that explained the most variance were used for the visual representation of the data. Still using the same correspondence analysis function in Tanagra, we plotted the structure of the data along the most informative axes (i.e. the axes that together explained the greatest part of the total variance). In this plot, we indicated the seven sub dimensions, all individual participants, and the average participant of each group.

[15] To download TANAGRA: http://eric.univ-lyon2.fr/~ricco/tanagra/en/tanagra.html
For detailed information of the Correspondence Analysis procedure, see the tutorial http://eric.univ-lyon2.fr/~ricco/tanagra/fichiers/en_Tanagra_Afc.pdf

## 5.3 Results

### 5.3.1 Attitude of teachers towards teaching science before the intervention

All teachers returned the questionnaire prior to the start of the intervention (for an overview see figure 2). Initially, the majority of the experienced teachers (75%) indicated that science was highly relevant in elementary education (perceived relevance). However, most of the participants (85%) reported that in general they believe that teaching science in elementary school is difficult (perceived difficulty). The responses to gender-related statements, which addressed the gender stereotypical beliefs about teaching science, varied between participants. Half of the teachers (51%) believed that teachers do not have stereotypical beliefs about teaching science and a minor group of the teachers (28%) thought teachers do. Within the affect dimension, the majority of the teachers (68%) reported positive feelings toward teaching science (enjoyment), but at the same time the majority (46%) reported that they felt nervous or anxious about teaching science. Within the last dimension of perceived control, teachers' responses reflected their beliefs about internal (self-efficacy) and external (context dependency) factors that might hinder teaching science in elementary classrooms. The opinions of teachers about self-efficacy were divided; on average, about one-third (32%) were negative responses and one-third (34%) positive responses. Remarkably, almost no teachers reported extreme positive or negative values. The participants also differed a lot with regard to how they perceive the influence of contextual factors on teaching science. The majority (79%) though, indicated that contextual factors play a major role, and that the availability of science methods or material is essential to teaching science.

All teachers in the control condition also completed the DAS questionnaire at time point 1 (for an overview see table 1). Within the cognitive beliefs dimension, most control teachers (67%) indicated that teaching science is very important in elementary education. Around one-third of the respondents (29%) indicated that teaching science is perceived as difficult for teachers. The majority of the participants (43%) responded that teachers do not have gender stereotypical beliefs regarding science teaching. A minority of the participants (17%) did indicate that they believe that there are gender differences with regard to teaching science. Within the affect dimension, most participants (71%) indicated that they had positive feelings toward teaching science (enjoyment). The majority (75%) also indicated that they felt (or would feel) anxious when teaching science. Within the dimension of perceived control, almost half of the teachers (42%) indicated that they felt capable of teaching science, whereas a minority (13%) responded in more negative way to statements concerning feelings of self-efficacy with regard to teaching science. The opinions of teachers about the influence of contextual factors on teaching science differed, but the majority (61%) indicated that they felt not so dependent on external factors such as science materials when teaching science.

All novice teachers also filled in the DAS questionnaire prior to the intervention. Within the dimension of cognitive beliefs, most novice teachers (55 %) valued teaching science as highly relevant in elementary education, whereas a minority (29%) did not perceive science

teaching as relevant. Most respondents (63%) indicated that science content is difficult for teachers and that teaching science is challenging. 21% reported that science content is not so hard to teach. With regard to gender stereotypical beliefs, the novice teachers indicated predominantly that there were no gender difference with respect to teaching science, but 25% reported that they believed there were differences. Within the affect dimension, the novice teachers predominantly reported that they enjoyed teaching science (47 %). A minority (13%) responded that they disliked teaching science. Over half of the novice teachers reported that they did not feel nervous when teaching science, whereas only 19% reported that they were nervous when teaching science. Within the dimension of perceived control, more than half of the novice teachers (58%) indicated low values of self-efficacy with regard to teaching science. Most of the participants (62%) indicated that external factors were not so important when teaching science, opposed to one-third (33%) of the participants who did value context as an important factor.

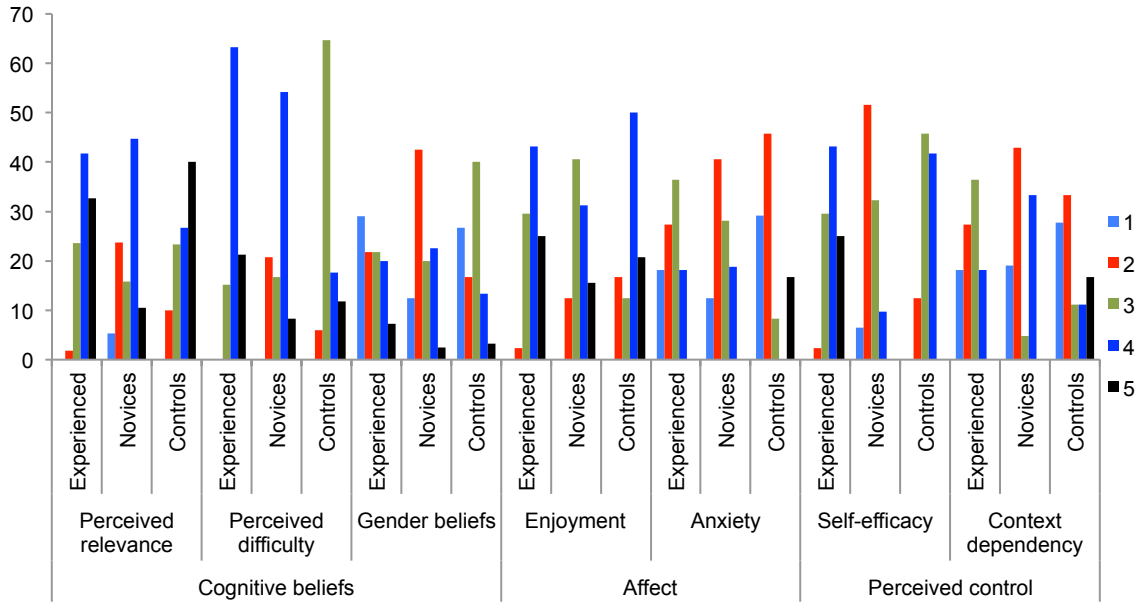


**Figure 2** Percentages of responses per Likert value (1-5) on the seven subscales of the DAS instrument completed by experienced, novice and control teachers.

### 5.3.2 Pre-intervention comparisons of attitudes between groups

The initial attitudes of teachers were compared to determine whether there were differences between experienced and novice teachers (see table 1). The results indicated that their beliefs towards teaching science differed for five out of seven sub dimensions: perceived relevance, perceived difficulty, enjoyment, self-efficacy, and context dependency. This means that the experienced teachers perceived teaching science as more relevant and more difficult to teach than the novice teachers. They also reported that they enjoyed teaching science more and that they felt more capable of teaching science. However, they felt more dependent on contextual factors than the novice teachers. Although the experienced teachers initially reported more

positive feelings and higher levels of self-efficacy than the novices, both groups showed a clear increase between pre- and post-intervention measure. Initially, the experienced teachers thought that science teaching was more dependent on contextual factors than the novices, but after the intervention both groups indicated that science teaching was less dependent on external factors.

**Table 1**
Comparisons of initial attitudes of experienced teachers and novice teachers

| | | Experienced teachers | Novice teachers | *p* | *d* |
|---|---|---|---|---|---|
| Cognitive beliefs | | | | | |
| | Perceived relevance | 4.05 | 3.30 | <.001* | 1.56 |
| | Difficulty | 4.06 | 3.50 | .006* | 1.42 |
| | Gender | 2.55 | 2.60 | .62 | -.08 |
| Affect | | | | | |
| | Enjoyment | 3.91 | 3.50 | .03* | .95 |
| | Anxiety | 2.55 | 2.53 | .53 | .04 |
| Perceived control | | | | | |
| | Self-efficacy | 3 | 2.42 | .003* | 1.41 |
| | Context dependency | 3.36 | 2.56 | .01* | 1.29 |

The initial attitudes of experienced teachers in the intervention group were also compared to teachers in the control group (see table 2). The comparisons between the intervention and the control condition also revealed differences on perceived difficulty and context dependency. Weak support was found for differences on self-efficacy. The results indicated that experienced teachers in the intervention group, on average, perceived teaching science as more difficult, felt less capable of teaching science and felt more dependent on contextual factors than teachers in the control group. Before the intervention, the attitude of experienced teachers in terms of enjoying teaching science was also more positive than the attitude of teachers in the control group.

**Table 2**
Comparisons of initial attitudes of teachers in the intervention condition and teachers in the control condition

| | | Intervention | Control | *p* | *d* |
|---|---|---|---|---|---|
| Cognitive beliefs | | | | | |
| | Perceived relevance | 4.05 | 3.84 | .20 | .46 |
| | Difficulty | 4.06 | 3.13 | <.001* | 3.31 |
| | Gender | 2.55 | 2.4 | .35 | .25 |
| Affect | | | | | |
| | Enjoyment | 3.91 | 3.6 | .11 | .71 |
| | Anxiety | 2.55 | 2.55 | .56 | 0 |
| Perceived control | | | | | |
| | Self-efficacy | 3 | 3.35 | .08 | -.87 |
| | Context dependency | 3.36 | 2.07 | .001* | 2.15 |

### 5.3.3 Comparisons of changes in attitudes within groups

Changes between pre- and post-intervention measures were compared within groups to investigate whether the average attitudes per group towards teaching science had changed over the course of the intervention[16]. Furthermore, the individual changes are discussed on the basis of scatterplots of the individual changes from pre- to post-intervention.

***Cognitive Beliefs.***

In the sub dimension perceived relevance, there were no indications of changes in the experienced teacher group, both intervention and control conditions. There was strong support with large effect for the finding that after participation in the intervention the novice teachers on average reported science teaching in elementary education to be more important ($p$ <.001, $d$ = .83). Figure 3 depicts the changes of each individual from pre- to post-intervention measure. From the graph of perceived relevance, it can be seen that five of the novice teachers showed positive changes, and three novices indicated similar levels of perceived relevance. However, the teachers in the control condition seem somewhat unpredictable: two teachers showed an increase from pre- to post-intervention, two showed a decrease, and one showed a nearly similar score at post-intervention measure. This increase was typical of the teachers who had a low score during the pre-intervention measure, and the decrease was typical of the teachers who had a high(er) pre-intervention score.

With regard to the sub dimension perceived difficulty, the experienced teachers – both in the intervention and the control group – indicated on average that science teaching elementary education was perceived less difficult. We found weak support for this difference in the intervention group ($p$ = .093, $d$ = -.36) and strong support in the control group ($p$ = .038, $d$ = -.77). This holds for almost all individuals, except for one experienced teacher (see figure 3). In the group of novice teachers, there seems to be more variation between individuals. Four novices indicated higher scores on perceived difficulty at post-intervention measure, whereas two showed a decrease. Another two novice teachers remained fairly similar after the intervention.

There were no indications of changes regarding gender beliefs. From figure 3, we can see that the changes between pre- and post-intervention, which are mainly negative, seem relatively small for most individuals. It also appears from the figure that there are differences in the distribution of the subgroups over the space. For instance, in the perceived relevance graph, the experienced teachers are typically in the middle, the novices are typically to the left and the controls are everywhere. This indicates that the novices seem to have the lowest feelings of perceived relevance, the experienced teachers seem to have the highest values, and the controls seem to vary greatly in perceived relevance. For this sub dimension, the subgroups of experienced and novice teachers seem more clearly demarcated. In the perceived difficulty

[16] In this paper, we only report the meaningful changes. For an overview of all pre- and post-intervention comparisons, see Appendix A.

graph, the subgroups are greatly overlapping, which is also the case in the gender beliefs graph.

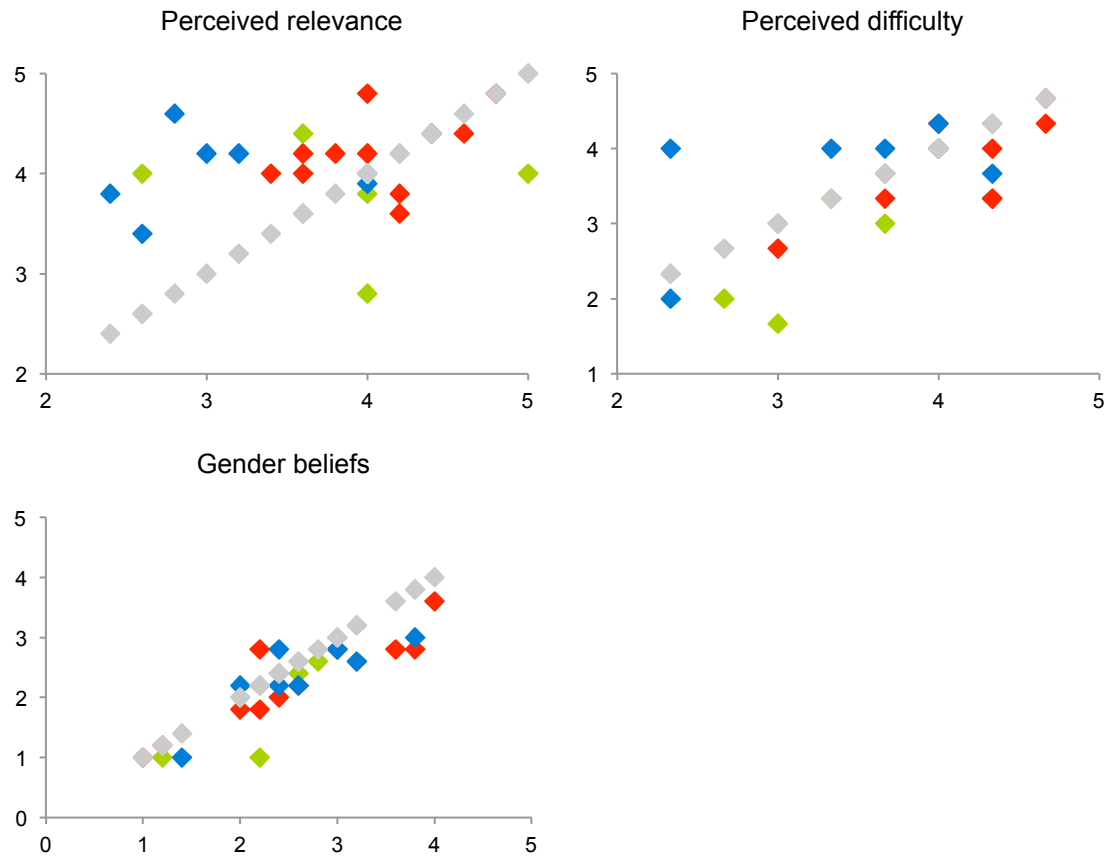


**Figure 3** Comparison of pre- and post-intervention measures of each individual who filled in the DAS questionnaire on the Cognitive Beliefs dimension. The grey diamonds (◆) indicate the so-called isocline based on scores during pre-intervention measure. For the grey diamonds, the x-axis and y-axis both represent the score at pre-intervention. The colored diamonds depict the score at post-intervention measure (◆ = experienced teacher, ◆ = novice teacher, ◆ = control teacher). For the colored diamonds, the x-axis represents the pre-intervention score, and the y-axis the post-intervention score.

***Affect.***

The pre- and post-intervention comparisons indicate that there is an effect of teaching science – compared to not teaching science, which was the case before participation in this study – on affect. Teachers in all three conditions experienced more enjoyment (experienced: $p < .001$, $d = .73$; novices: $p < .001$, $d = 1.18$; control: $p = .002$, $d = 1.00$) and less anxiety towards teaching science (experienced: $p < .001$, $d = -.91$; novices: $p = .001$, $d = -.85$; control: $p < .001$, $d = -1.07$). The probability that these differences were based on chance alone were very low in all groups, and in combination with a large effect this provides strong support for average changes in the affect dimension. In figure 4, the pre- and post-intervention scores of each individual are plotted. It shows that the increase in enjoyment applies to nearly all individuals. Two experienced teachers and one novice showed only a slight decrease in enjoyment. In the group of control teachers, there are two individuals that showed no change from pre- to post-intervention, but

there is also one individual that showed a large increase in enjoyment (outlier). With regard to anxiety, it can be seen from figure 3 that almost all individuals reported lower levels of anxiety at post-intervention measure. Again, there is one individual who showed a large decrease in anxiety. This is the same control teacher who showed the large increase in enjoyment. From this figure, we can also see that the subgroups of teachers are greatly overlapping, and that there is no clear demarcation between the groups. This holds for both the graph of enjoyment and anxiety.

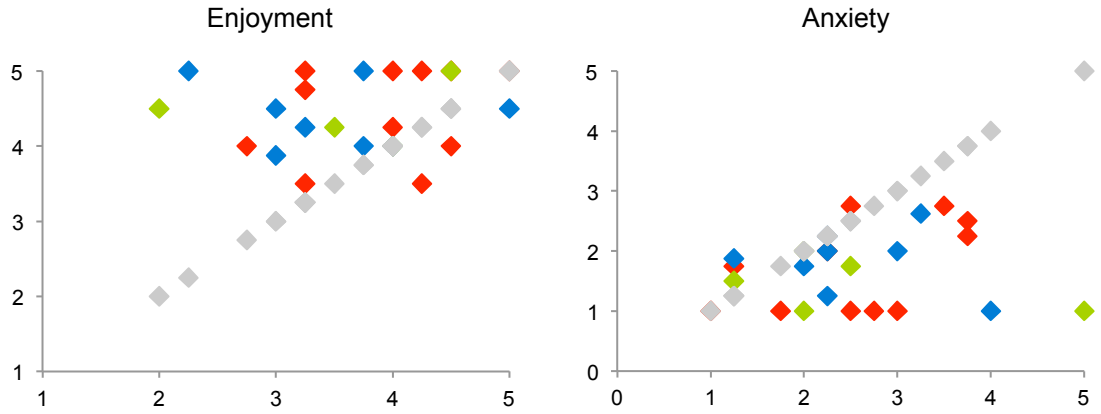


**Figure 4** Comparison of pre- and post-intervention measures of each individual who filled in the DAS questionnaire on the Affect dimension. The grey diamonds (◆) indicate the so-called isocline based on scores during pre-intervention measure. For the grey diamonds, the x-axis and y-axis both represent the score at pre-intervention. The colored diamonds depict the score at post-intervention measure (◆ = experienced teacher, ◆ = novice teacher, ◆ = control teacher). For the colored diamonds, the x-axis represents the pre-intervention score, and the y-axis the post-intervention score.

***Perceived control.***

In the dimension of Perceived Control, all teachers who participated in the intervention – experienced as well as novice teachers– demonstrated effects. After the intervention, they reported that they felt more capable of teaching science (self-efficacy) and they believed that teaching science was less dependent on contextual factors (context dependency). We found strong support for these differences as the probability that these differences were based on chance alone were very low in combination with moderate to large effects for self-efficacy (experienced: $p$ =.002, $d$ = .56; novices: $p$ <.001, $d$ = 3.31) and context dependency (experienced: $p$ = .002, $d$ = -.78; novices: $p$ = .002, $d$ = -.86). After teaching science for a short while, teachers in the control group, on average, indicated that teaching science was somewhat less dependent on the context. We found weak support for this difference between pre- and post-intervention measures ($p$ = .089; $d$ = -.60). Figure 5 presents the changes in individual attitudes from pre- to post-intervention measure. From the plot of self-efficacy, we can see that there were no novices that showed a decrease and their changes were relatively large. In the experienced teacher group, the differences between measures seemed slightly smaller, and there were two individuals who showed a decrease in self-efficacy. The control group seemed somewhat unpredictable: one individual clearly showed positive change, and one clearly

showed negative change, whereas the others remained fairly similar. With regard to context dependency, there seems to be a lot variation between individuals in the experienced teacher and the novice teacher group. This variation is visible both at the start (pre-intervention measure) and in the change between pre- and post-intervention measures. It shows from the graph that changes in the control group are limited: only one individual showed a clear decrease whereas the other controls stayed about the same. This figure also illustrates the distribution of the subgroups. In the self-efficacy picture, we can see that some subgroups, the experienced teachers and the controls, seem divided into a group on the left side of the space (representing lower scores) and a group on the right side of the space (representing higher scores). The variation in the subgroup of novices seems somewhat smaller, and is more concentrated on the left side and middle of the space. With regard to context dependency, the subgroups are greatly overlapping. However, the controls are clearly distributed in the middle part of the space, and the experienced teachers are more on the middle and right part of the space.

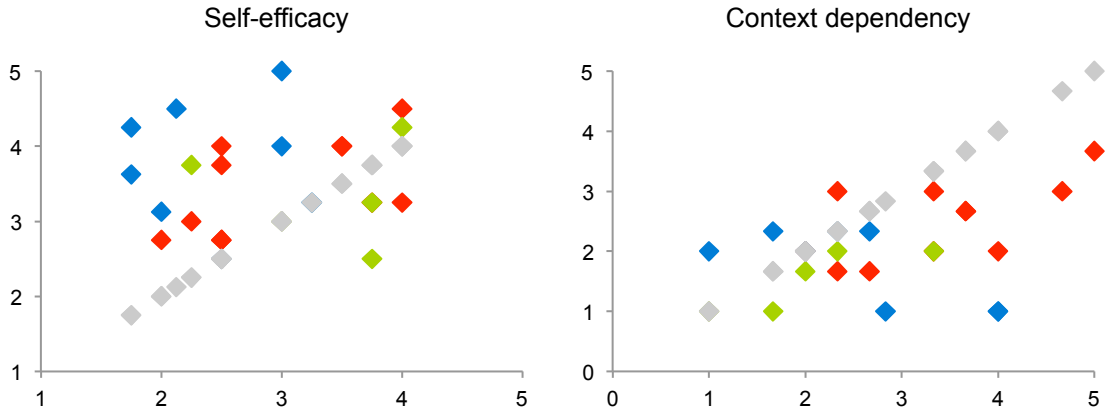


**Figure 5** Comparison of pre- and post-intervention measures of each individual who filled in the DAS questionnaire on the Perceived Control dimension. The grey diamonds (◆) indicate the so-called isocline based on scores during pre-intervention measure. For the grey diamonds, the x-axis and y-axis both represent the score at pre-intervention. The colored diamonds depict the score at post-intervention measure (◆ = experienced teacher, ◆ = novice teacher, ◆ = control teacher). For the colored diamonds, the x-axis represents the pre-intervention score, and the y-axis the post-intervention score.

### 5.3.4 Comparisons of changes in attitudes between experienced and novice teachers

In order to assess whether the changes of the novices were larger than the changes in the experienced teacher group, we compared the average change from pre- to post-intervention measure. The results are presented in table 3. From this table, we can see that the change in the novice teacher group was larger for perceived relevance. We found weak evidence that the probability that this difference was based on chance alone was relatively low ($p$ = .06, $d$ = 1.00). With regard to self-efficacy, the novices also showed a larger increase than the experienced teachers. In this case, we found strong evidence supporting the hypothesis ($p$ = .05, $d$ = 1.08).

**Table 3**
Comparisons of average changes in attitudes of experienced teachers and novice teachers

| | | Experienced teachers | Novice teachers | *p* | *d* |
|---|---|---|---|---|---|
| Cognitive beliefs | | | | | |
| | Perceived relevance | .16 | .76 | .06* | 1.00 |
| | Difficulty | -.27 | .25 | .11 | .90 |
| | Gender | -.29 | -.25 | .48 | .10 |
| Affect | | | | | |
| | Enjoyment | .55 | .89 | .25 | .37 |
| | Anxiety | -.82 | -.69 | .41 | .13 |
| Perceived control | | | | | |
| | Self-efficacy | .45 | 1.36 | .05** | 1.08 |
| | Context dependency | -.88 | -.81 | .46 | .06 |

### 5.3.5 Underlying structure of attitudes

In order to understand the underlying structure in the data, we conducted a correspondence analysis on all sub dimensions of each individual in the three groups (i.e. experienced teachers, novices, and controls). The results of the correspondence analysis on the pre-intervention measures are presented in table 4. These findings show that the first two axes together explain the largest part (69.88%) of the variance. The scatterplots on the left in figure 8 and 9 are therefore based on these two axes. Figure 8 depicts the structure of the sub dimensions (or variables) relative to each other in the two-dimensional coordinate space and figure 9 depicts the relative positions of the individual teachers in the plot. Figure 8 shows that the space can be described by two dimensions: on the horizontal axis there is a dimension of high self-assurance versus low self-assurance and on the vertical axis there is a dimension of person specific versus context specific regarding perceived difficulty and enjoyment towards teaching science. On the left extreme of the horizontal axis is self-efficacy, closely followed by enjoyment and perceived relevance. This is in contrast to the right extreme of anxiety followed by context-dependency and gender beliefs, which can be interpreted as a lack of self-assurance and perceived relevance. On the vertical axis, the extreme positions are, on the upper part, gender beliefs followed by anxiety and self-efficacy and, on the lower part, context-dependency followed by perceived difficulty. This could be interpreted as a dimension that characterizes the perceived difficulty and enjoyment in terms of person specific versus context specific factors. With regard to the individual teachers, it becomes clear from figure 9 that the individual participants are scattered over the grid. The seemingly large variation between individual teachers (small colored diamonds) appears much larger within groups, than between the groups (based on the average participant per group, depicted by large symbols). One remarkable observation is that the control teachers – except one – seem to be positioned quite closely to one another (upper left), and that one control teacher has a very different position in the plot (upper right).

**Table 4**
Eigen values and explained variance of correspondence analysis of pre-intervention measures

| Axis | Eigen value | % explained | % cumulated |
|---|---|---|---|
| 1 | 0.027487 | 47.98% | 47.98% |
| 2 | 0.012541 | 21.89% | 69.88% |
| 3 | 0.006541 | 11.42% | 81.29% |
| 4 | 0.005858 | 10.23% | 91.52% |
| 5 | 0.003116 | 5.44% | 96.96% |
| 6 | 0.001742 | 3.04% | 100.00% |
| Total | 0.057284 | | |

Table 5 provides the results of the correspondence analysis at post-intervention measure. The first two axes are again the most important: together these axes explain the largest part (67.06%) of the variance, and therefore these axes are used to plot the coordinates in the scatterplot to show the underlying structure of the sub dimensions (see right plot in figure 8). From this figure, we can see that the overall structure of the sub dimensions is quite similar to the structure at pre-intervention measure. On the horizontal axis, the extremes are still self-efficacy and anxiety. The extremes on the vertical axis are gender beliefs and context dependency. The other sub dimensions are very close to each other and are all around the midline. As can be seen in figure 9, the differences between the average participant of each group (the large symbols) seem somewhat smaller, but the relative positions of the individuals still seem to show very large inter individual differences.

**Table 5**
Eigen values and explained variance of correspondence analysis of post-intervention measures

| Axis | Eigen value | % explained | % cumulated |
|---|---|---|---|
| 1 | 0.017479 | 43.31% | 43.31% |
| 2 | 0.009582 | 23.75% | 67.06% |
| 3 | 0.005653 | 14.01% | 81.07% |
| 4 | 0.004444 | 11.01% | 92.08% |
| 5 | 0.002396 | 5.94% | 98.02% |
| 6 | 0.000799 | 1.98% | 100.00% |
| Total | 0.040354 | | |

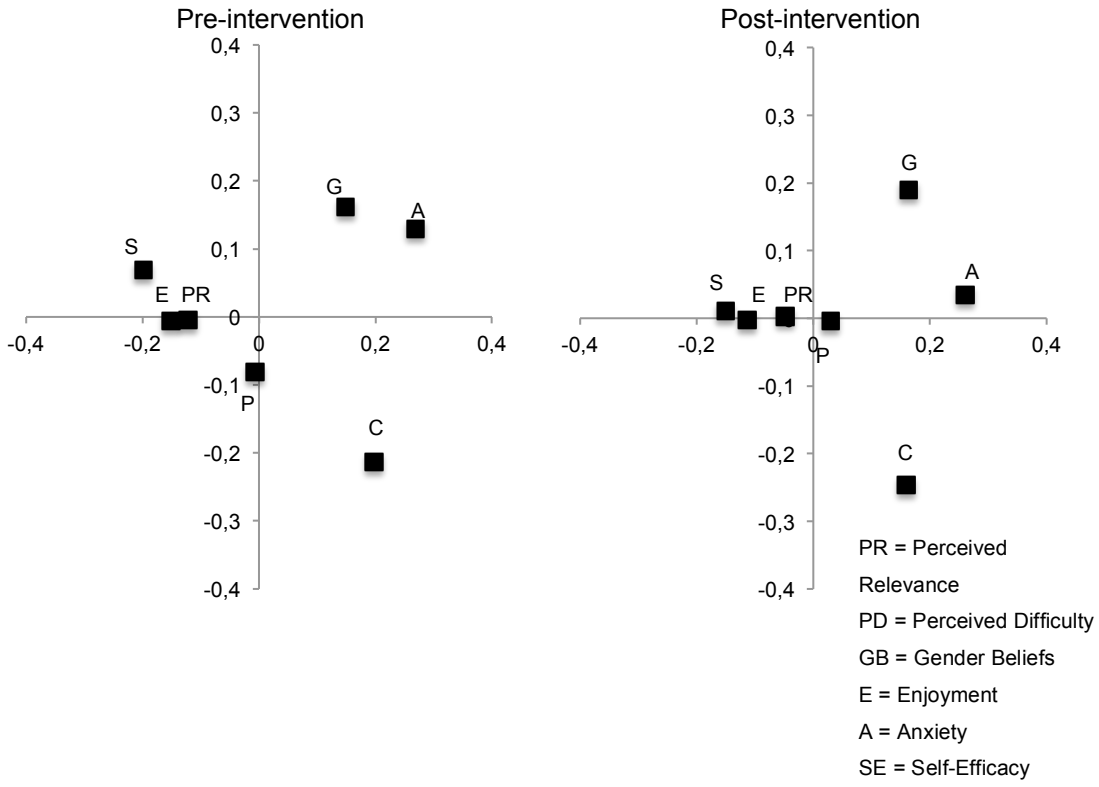


**Figure 8** The two most important coordinates resulting from Correspondence Analysis of pre- and post-intervention measure plotted, in which the x-axis represents the first axis and the y-axis represents the second axis. The black squares depict the relative positions of the subdimensions (or variables) in the two-dimensional space.

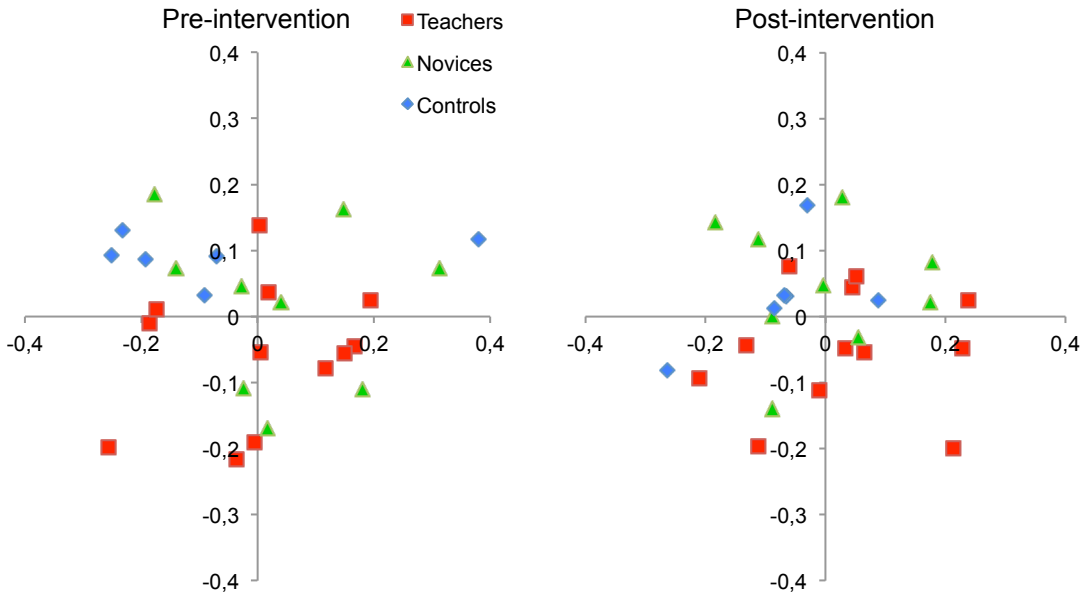


**Figure 9** The two most important coordinates resulting from Correspondence Analysis of pre- and post-intervention measure plotted, in which the x-axis represents the first axis and the y-axis represents the second axis. The small symbols depict the relative positions of individual teachers, and the larger symbols depict the average participant in each group.

## 5.4 Discussion

The aim of this study was to gain insight into the attitudes of teachers towards teaching science in early elementary classrooms and the extent to which attitudes differed after a video feedback coaching intervention for teachers. Moreover, the differences between teachers with a different degree of teaching experience were explored. Firstly, contrary to our expectations, we found strong support for differences before the start of the intervention between teachers in the intervention condition and teachers in the control condition. These differences concerned perceived difficulty and context-dependency in the way that, on average, the control teachers reported lower initial values than the intervention teachers. As we expected, there were large differences between attitudes of experienced and novice teacher before the start of the intervention. The novices reported lower values on perceived relevance, difficulty, enjoyment, self-efficacy, and context dependency. This means that novices found teaching science less relevant, they experienced less enjoyment when teaching science, and they felt less capable of teaching science. However, they also perceived teaching science as less difficult and less dependent on the context.

Secondly, we found evidence for the hypotheses that the attitudes of teachers in the intervention conditions – both experienced and novices – changed in a positive way after the intervention. The attitudes of both types of teachers changed on the sub dimensions of enjoyment, anxiety, self-efficacy, and context dependency. For the experienced teachers, we also found a positive change regarding perceived difficulty, and for the novices a change in perceived relevance. The results also showed that novices show greater improvement than experienced teachers for self-efficacy and perceived relevance, but not for the other dimensions. With regard to the control group, contrary to our expectations, they showed positive changes in attitudes on the sub dimensions of enjoyment and anxiety, perceived difficulty, and context-dependency.

Thirdly, visual inspection of the scatterplots of changes in attitudes seemed to demonstrate that there were large differences between individual teachers. The graphs showed that – for some of the sub dimensions – the variation within groups seemed just as large as the variation between groups.

The last part of this study addressed the exploration of the underlying structure of the attitudes. The overall structure of the teacher attitudes remained fairly similar from pre- to post-intervention. For the different groups of teachers, the structure was also comparable. This implies that although the individuals show changes in their attitudes in the course of the intervention, the underlying structure of the instrument is unchanged. In general, the space can be described by two dimensions: a dimension of high self-assurance versus low self-assurance and a dimension of person specific versus context specific regarding perceived difficulty and enjoyment towards teaching science.

### 5.4.1 Interpretation of results

Experienced teachers (in both conditions) already indicated (on average) that science education was highly relevant in elementary school at pre-intervention measure. Although many studies report that teachers have negative feelings toward teaching science (Appleton, 2003; Eshach, 2003; Greenfield et al., 2009; Murphy et al., 2007; Kallery, 2004; Osborne et al., 2003; Pederson & McCurdy, 1992; Sackes et al., 2011; Tu, 2006; Watters et al, 2000; Wenner, 2001), our results indicate that they do see the relevance of early elementary science education. This finding seems in line with studies indicating that the concerns teachers have are mainly concentrated on practical and organizational issues and feelings of incompetence (Appleton, 2003; Eshach, 2003; Greenfield et al., 2009; Murphy et al., 2007; Kallery, 2004; Osborne et al., 2003; Pederson & McCurdy, 1992; Sac¸kes et al., 2011; Tu, 2006; Watters et al., 2000; Wenner, 2001). The novices, who initially reported lower levels of perceived relevance, showed an increase at post-intervention measure. Experienced teachers in both conditions also showed a decrease in perceived difficulty. This suggests that doing science – rather than being coached how to optimize teaching skills regarding science – contributes to the feelings of teachers that science is not as difficult to teach as they initially may have thought.

One of the most striking results is the change in the affect dimension of all groups of teachers in this study. It is remarkable that teachers in the control condition, who did not receive the individual video feedback coaching, also indicated lower levels of anxiety and higher levels of enjoyment at post-intervention measures. There are some possible factors that may explain these results. Firstly, part of the change may be due to the fact that teachers were asked to reflect on their attitudes with regard to teaching science in the form of the questionnaire that we administered. But it is interesting – and in fact very important – that there was no change in the corresponding teaching behavior (such as posing open-ended questions and using complex and sophisticated language) in the control group, whereas teachers in the intervention condition did show changes in teacher behavior after the intervention (see Chapter 4). This is in accordance with previous studies stating that teachers' beliefs and perceptions are often incongruent with their actual teaching practices (Bryan & Abell, 1999; Breen et al., 2001; Feryok, 2004; Mitchell, 2005; Pham & Hamid, 2013; Wang, Chai, & Hairon, 2016).

Secondly, the fact that teachers experience the curiosity of their students while carrying out experiments using simple materials may have contributed to positive changes in the control group. Teachers often realize that the choices of topic and materials are important, but that they are not necessarily complicated. Nevertheless, after the intervention, experienced teachers and novice teachers reported that they had more knowledge about and more confidence in teaching science. They indicated that teaching science is less dependent on contextual factors such as standardized methods or curricula, which means higher self-efficacy. Teachers in the control condition, however, did not report higher levels of perceived control and self-efficacy with regard to teaching science. These teachers still had the feeling that teaching science in a good way is very dependent on contextual factors. However, control teachers still found it important to have an established method for science in early elementary school. The findings of more positive

feelings towards teaching science and higher feelings of control at post-intervention measure may contribute to the continuation of teaching science (Van Aalderen-Smeets & Walma Van der Molen, 2013). In order to improve the quality of science teaching – and in the end, provide better learning opportunities for students –, teachers need support and guidance of an expert.

Thirdly, our results contradict the results of Van Vondel (2016). She compared attitudes of upper grade elementary teachers before and after a similar professionalization intervention, and found no differences in the control group. We speculate that this discrepancy is related to the observation that early elementary teachers often immediately experience the enthusiasm of their students when engaging in science activities. Moreover, our study concerned small teaching groups in contrast to the whole classroom setting in the study of Van Vondel (2016). Personal experiences of the early elementary teachers also revealed that organizational issues were the most hindering factors with regard to continuing teaching science in the whole classroom setting. In small teaching groups, teachers are less concerned with organizational issues and classroom management. In previous research, classroom management was one of the worries of novice teachers (Murphy & Smith, 2012). In line with Lotter (2004), who found that most points of teacher frustration during science activities were related to negative student attitudes, we speculate that the experiments in the small teaching groups triggered the students' enthusiasm immediately as opposed to the worksheets a lot of upper grade teachers used to teach science in a whole classroom setting.

Finally, in the data of the control group, we observed that one individual clearly differed from the other individual in this group with regard to enjoyment and anxiety. This observation suggests that the changes in the control were in part due to the extreme scores of this individual.

The findings of this study indicate that teaching experience plays a role in the attitudes teachers have towards teaching science, and is of influence on the possibility to change these attitudes. Initially, the difference between both groups in their perceptions and beliefs with regard to science education were very pronounced. In line with Lumpe et al. (2000), our results indicated that experienced teachers had initially more positive feelings of perceived control compared to novice teachers. In contrast to previous research, the novice teachers in this study were less concerned about contextual factors such as methodologies for science teaching (Murphy & Smith, 2012). However, the groups in this study are small, and we found such considerable differences between individuals, which were in fact much greater than the differences in averages. The idea that novice teachers improve more than experienced teachers fits with our findings of initial differences between attitudes of experienced and novice teachers, and the fact that the novices' attitudes changed in most domains (Clotfelter et al., 2007; Harris & Sass, 2007; Kane et al., 2006). The discrepancies in attitudes of teachers toward teaching science emphasize the importance of looking at individual attitude patterns, as was suggested by Van Aalderen-Smeets and Walma Van der Molen (2013), to gain better insight in personal attitudes and the individual patterns of change.

The fact that we found changes in the sub dimensions of enjoyment, anxiety, self-efficacy, and perceived relevance may not be surprising. Other studies already demonstrated close associations between enjoyment and anxiety (Lumpe et al., 2000; Van Aalderen-Smeets et al., 2012). From existing research we know that self-efficacy is bidirectional in the way that teachers' self-efficacy is related to good outcomes of students and that good outcomes of students enhance teachers' self-efficacy (Rose, 1998). The LaT intervention, which addressed the teachers' self-efficacy by providing them with individual video feedback coaching based on their own personal learning goals, had positive impact on student outcomes in terms of more reasoning expressions and more complex language (see Chapter 4). This is in line with previous studies which showed that positive feelings and feelings of being in control (self-efficacy) towards teaching science are related to behavioral change of teachers (Haney et al., 1996; Van Aalderen-Smeets & Walma Van der Molen, 2013). Finally, these results suggest that together with changes in enjoyment, anxiety, and self-efficacy, participants view teaching science in elementary classrooms as more important, which is very promising in the light of improving early elementary science education.

The exploration of the underlying structure of attitudes towards teaching science indicated that the structure pre-intervention was comparable to post-intervention. These findings support the use of the DAS instrument in intervention studies. The robust factorial structure of the DAS offers the possibility to map changes in attitudes across an intervention.

### 5.4.2 Limitations and future research

An interesting suggestion for future research is to investigate the changes in attitudes in combination with the changes in behavior on an individual level. This may provide information on how attitude and behavioral change are related. This knowledge may be important for designing, improving, and implementing teacher professionalization interventions.

Whether the positive effects on teachers and students are strong enough to make a lasting impression can only be assessed through longitudinal research (Han & Weiss, 2005; Noell et al., 1997). The natural classroom setting in which the intervention took place, however, offers good opportunities for teachers to continue applying and expanding their learned skills in their daily teaching routines. If teachers have more positive attitudes toward teaching science, and if they feel more capable of doing so, the probability that they continue teaching science increases (Van Aalderen-Smeets & Walma Van der Molen, 2013).

Maybe one of the most interesting conclusions that we can draw from our data is that the individual differences within the groups greatly outweigh the differences between the group averages. Visual inspection of the graphs shows that the group average —e.g. of experienced teachers— is not a representation of the average group member, if by average group member we mean the typical person that forms the majority in this particular group, or whose properties are typical of a majority of group members. Of course, averages –even small ones— are important in large scale studies or large scale interventions where individual variation is hardly relevant for the question of average effectiveness, for instance in large scale policy decisions.

However, interventions such as the one described in the current article primarily concern individuals, and individuals are characterized by idiosyncratic properties that are likely to interfere with the course and actual nature of the intervention given. For all these reasons, we recommend that intervention studies should also focus on responsiveness of individuals, rather than focusing only on group averages. In principle, a better understanding of the reasons why interventions succeed in individual cases – or why individuals sometimes improve without any intervention given – might lead to improvements in those interventions. Such improvements will then be observable in the effectiveness of the intervention on the level of large-scale group comparisons.